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ABSTRACT

Research findings suggest the existence of three types of primitive regulation in the behavior of 1 1/2- to 2 1/2-year old children in memory tasks. When children are presented with a game of hide-and-seek to be played with a small stuffed animal, regulatory behavior appears to be related to children's use of stimulus information, precursors of mnemonic strategies, and organization of memory-based strategies. Concerning use of stimuli, evidence indicates the existence of a developmental progression in very young children's use of available cues and suggests that very young children's spontaneous behavior in memory tasks is in many ways analogous to later, more sophisticated strategies. In reference to mnemonic strategies, children exhibited task relevant vocalization, looked or pointed at the object's hiding place, hovered near, peeked at the toy, and attempted to retrieve it before a designated time. These behaviors resemble the mature mnemonic strategies of rehearsal and monitoring, and could function to keep alive information to be remembered. Regarding strategy organization, older and younger children whose mean ages were 27- and 21-months, respectively, were found to exhibit qualitatively different searching strategies after a hidden object had been surreptitiously moved. Younger children tended to search in places where the object had previously been hidden, whereas older children may have generated plausible hypotheses to explain the toy's absence, which then guided their subsequent search efforts. (Concluding remarks indicate limitations on children's early self-regulation and suggest how children overcome such limitations. (RH)

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OH WHERE, OH WHERE:

MEMORY-BASED SEARCHING BY VERY YOUNG CHILDREN[1]

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Running Head: Memory-based search

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One important type of spatial skill that emerges early yet undergoes considerable further development is memory for the location of objects. The extensive literature on object permanence (Gratch, 1975; Harris, 1975, in press) has amply documented the emergence at around eight months and the refinement over the next several months of the ability to remember not only the existence but also the location of a hidden object. Recent naturalistic studies have testified to the salience of location in a variety of early mnemonic activities. Parental diary records indicate that nearly a quarter of all identified memory episodes of 7- to 11-month-old infants involve remembering the location of an object or a person (Ashmead & Perlmutter, 1980). Location also seems to be a highly salient cue for recall memory; Nelson and Ross (1980) reported that half the recall episodes in the diary records of mothers of 20- to 30-month-olds were stimulated or cued by the location where the remembered object or event had been experienced. And Ratner (1980) found that one of the most frequent categories of memory demands placed on young children by their parents is for the recall of location information ("Where did you leave your shoes?").

Spatial cognition is thus implicated in early memory, and the interface between the two early skills is worthy of study. In addition, tasks that require the young child to remember the location of an object in the environment provide a window on early signs of mnemonic regulation. Very young children are cooperative and competent in such situations earlier than in memory tasks requiring verbal recall (Perlmutter & Myers, 1979); children who are unable or unwilling to retrieve verbal information from memory will readily retrieve objects from the environment (Brown & DeLoache, 1978; Wellman & Somerville, 1980). Since regulatory skills are more likely to be used in planning and executing tasks that subjects can comprehend and are motivated to perform (DeLoache, 1980; Shatz, 1978), such skills should be exercised relatively early in object retrieval tasks.

In this paper, we will consider the questions of how, and how well, the very young child remembers where in space he last saw a given object. The

answer to the quantitative question--"how well does the young child remember spatial location?"--is clear, as I will illustrate shortly. The answer to the qualitative question--"how does the young child go about remembering?"--is less clear, and most of this paper will be devoted to it.

For the ensuing discussion, we must distinguish between natural memory and mediated memory. Natural memory refers to memory that occurs as a consequence of meaningful activity; no deliberate or conscious effort is required. In mediated memory, the person engages in some activity in the service of remembering. What a person remembers is a product of deliberate mnemonic activity. Similar distinctions have often been made in the memory literature, including voluntary vs. involuntary, intentional vs. incidental, and effortful vs. non-effortful memory. In this paper I will first discuss natural memory with respect to very young children remembering in what spatial location an object has been hidden. Second, I will discuss evidence of mediated memory in very young children, evidence that suggests that even children below the age of two may in some situations engage in very simple forms of explicit mnemonic activity.

Natural Memory for Location

With respect to the question of "how well" young children remember location, the answer is, "very well indeed." From at least 18 months of age, memory for the location of a hidden object is extremely good, especially when the object is hidden in the natural large-scale environment. This assertion is based on several studies investigating the ability of children between 18 and 30 months of age to remember the spatial location of a hidden object (DeLoache & Brown, 1979, 1983, in press; DeLoache, Cassidy, & Brown, 1983).

The memory task that we have used in this research is presented to the child as a game of hide-and-seek to be played with a small stuffed animal. The children are told that Big Bird is going to hide and that they should remember where Big Bird is so they can find him later. The child then watches

while the toy is hidden in some natural location in the large-scale environment, often in the child's own home. The hiding locations consist of places common to almost any living room, such as under a couch or chair cushion, behind a door, inside a cabinet, and so forth. A timer is set for a specified interval, and the child is told that when the bell rings, he can go find the toy. During the interval, the children are usually engaged in talking or playing with the experimenter. The children readily apprehend the goal and the rules of the game, and most of them greatly enjoy playing it.

In several studies using the basic task, our young subjects have exhibited excellent memory for the location of an object hidden in the large-scale environment. The level of performance across the studies is quite high, averaging well over 80 percent errorless retrievals. (Errorless retrieval is defined as the child searching first at the correct location.) We have, in fact, often obtained ceiling memory performance from two-year-old children.

The robustness of young children's memory for spatial location is also reflected by the fact that the rate of errorless retrievals is only minimally affected by a number of variables that one might a priori assume would affect it. For one thing, the age of the children has not been consistently related to memory performance. In some studies we have found significant age differences, with older subjects between 24 and 30 months outperforming younger 18- to 24-month-olds, but in others no age effects appeared. Thus, there may be a small degree of developmental change in memory for spatial location over this age period, but even 1½-year-olds generally perform quite competently in the basic task.

Memory for the location of an object also seems to be relatively impervious to the length of time the child must remember; we have found little change in performance over intervals ranging from a few minutes to several hours. Amount

of experience with the hide-and-seek game does not affect the rate of errorless retrievals; children given pre-training on the task do not do better than children participating in it for the first time, and performance generally remains stable over days. It does not make any difference whether the children are verbally instructed to remember the toy's location or not; subjects told to "be sure to remember where Big Bird is so you can find him" do not do better than children who are given no memory orientation. It also does not matter whether the task is embedded in a familiar or unfamiliar environment; errorless retrievals are equivalent whether children are observed in their own homes or in an unfamiliar laboratory playroom.

In other words, it seems to be fairly difficult to degrade young children's memory for where an attractive toy is hidden within a natural, large-scale environment. Performance is often near ceiling, and it remains near ceiling through the various manipulations just described. Young children generally remember the location of a hidden toy, and they do so with no obvious mnemonic effort. Thus, with respect to the basic task, the answer to the "how" question seems to be, "naturally." Memory for location emerges as a consequence of the meaningful activity of a hiding and finding game that young children readily engage in.

Mediated Memory for Location

But, what about other situations? What if more than natural memory is required for success? Are young children in any way sensitive to memory demands or capable of any deliberate mnemonic effort? This question is the primary focus of the research that will be described in this paper. We will consider the emergence and early development of self-regulatory skills. These skills are the various processes by which people organize their thoughts and actions (Brown, 1978; Brown & DeLoache, 1978), including activities such as planning

ahead, predicting the outcome of some action (what will happen if?), monitoring ongoing activity (how am I doing?), checking on the results of actions (did that work, did it achieve my goal?), correcting errors or inadequacies (since what I just did didn't work, what would be a reasonable thing to try now?). These general skills are the basic characteristics of efficient thought throughout life.

Where do these important cognitive skills come from? We assume they do not spring full-blown from the brow of the young child, and yet, the general picture that is painted in the memory development literature is more like an all-or-none phenomenon. Older children are known to be (or at least capable of being) strategic and planful. Younger children, that is, preschool children, are not those same things. They are assumed to be incapable of being strategic or planful, and, indeed, most of the evidence supports this negative view of the young child as nonstrategic (Brown & DeLoache, 1978).

The research presented here disputes this view. I will sketch for you a new picture of the young child, who in some situations does seem to behave strategically, albeit in limited and primitive ways. We have used the hide-and-seek task, but we have varied it to go beyond the simple assessment of natural memory and to look for evidence of very early self-regulation, i.e., of strategic activity in very young children. We have obtained evidence of three types of primitive regulation in the behavior of 1½- to 2½-year-old children in the hide-and-seek and related memory tasks. In each case, I will first describe very briefly the mature form of the regulatory behavior typically observed in older individuals' performance, and then I will describe our analogous findings with respect to very young children's memory for the spatial location of a hidden object.

Exploitation of Stimulus Information

The first issue to be discussed concerns children's use of information to encode the location of a hidden object and to retrieve it later. With older subjects, the general pattern of results has been that developmental differences are found when cues are available to be strategically exploited, but no age differences appear when mnemonic strategies are not applicable. For example, in a recognition memory task requiring recency judgments, Brown (1975) and Brown, Campione, and Gilliard (1974) found no age differences between second and fourth grade subjects when no supplementary cues were available. When contextual, spatial, or color background cues were provided, the older children outperformed the younger ones, who failed to take advantage of the additional cues. Training the younger children to use these cues eliminated the developmental differences. This pattern of results was interpreted in terms of mnemonic strategy development. Older children strategically exploited the available cues to enhance memory, and they did so spontaneously. Less mature children needed training to use the cues effectively.

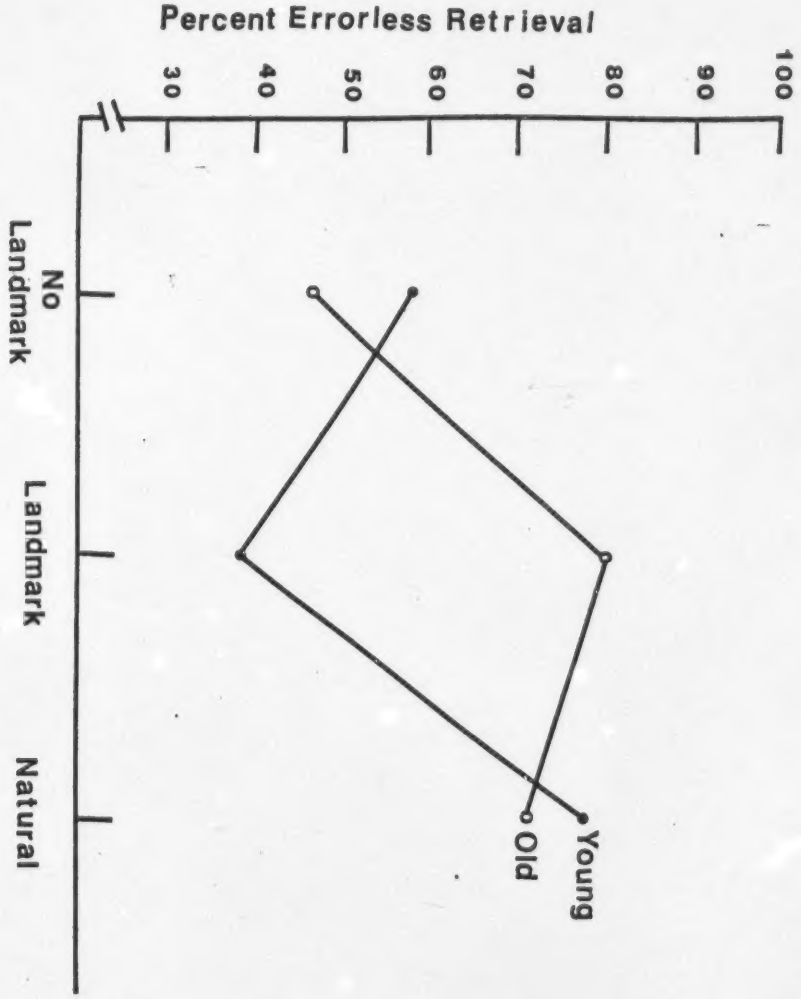
An analogous experiment was designed for very young children (DeLoache & Brown, 1983). Each child participated in three conditions, which differed in terms of the type of cues available. In two of the conditions, there were no special cues for identifying the correct hiding place. The first condition (Natural) was the basic hide-and-seek task, in which a toy was hidden in natural locations in the large-scale environment (the child's own home). The toy was always hidden in, under, or behind pieces of furniture. In the second condition (No Landmark), the toy was placed inside one of four small boxes arranged in the center of the room. The boxes were identical, so their relative position was the only cue to the correct one. In the third condition (Landmark), contextual cues were provided that could be used to retrieve the toy, if the child thought to use them. The toy was again hidden in one of four identical boxes, but this

time each of the boxes was placed on or near a piece of furniture. Thus, the furniture was a potential cue, a landmark denoting the correct one of the four boxes.

Notice that the relevant information was the same in both the Natural and the Landmark conditions; what differed was whether the subject merely had to notice the item of furniture itself or had to recognize its relation to the box with the toy. In the Natural condition the child only has to notice that the toy was hidden in the armchair, while in the Landmark condition he must notice that the box in which the toy was hidden was the one on the armchair. Thus, in the Natural condition the information is intrinsic to the hiding place, while in the Landmark condition, the child himself must link or integrate the information with the actual hiding place.

We compared the rate of errorless retrievals in these three conditions for a younger group of subjects whose mean age was 21 months and an older group with a mean age of 26 months. As shown in Figure 1, a clear interaction occurred, with an age difference in the children's performance in the Landmark condition, but not in the other two conditions. In the No Landmark condition, where the toy was hidden in one of four boxes in the center of the room, the old and young groups were at the same level. (Their performance is equivalent to that generally reported for similar delayed response tasks, e.g., Blair, Perlmutter, & Myers, 1978; Horn & Myers, 1978). Both age groups did substantially better in the Natural condition, the standard hide-and-seek task, and again there was no difference between them. (The general level of performance in the Natural condition is comparable to results we have obtained in other studies with the hide-and-seek task, e.g., DeLoache & Brown, 1979). The large difference in the performance of the two age groups in the Landmark condition indicated that the older children exploited the available landmarks, but the younger ones did not.

Figure 1. Errorless retrievals as a function of the type of hiding place. The apparent age x condition interaction is significant. (DeLoache & Brown, 1983)



The pattern of results for the three conditions combined thus reveals an absence of developmental differences in searching for a hidden object when no supplementary cues are available (No Landmark) and when distinctive cues are intrinsically associated with the hiding location (Natural). When potential cues are available, but have no inherent relation to the hiding place (Landmark), clear developmental differences emerge, with older children capitalizing on their presence and younger children failing to do so. These data may reflect an early form of mnemonic regulation. The older subjects may have done so well in the Landmark condition because they actively integrated the landmark cue with the relevant box. That is, at the time of hiding they noticed and encoded the relationship between the baited box and the nearby piece of furniture and then at retrieval used that information to direct their search. The younger subjects may have failed to encode the relationship in the first place or they may have neglected to draw on that information for retrieval.

In a subsequent study (DeLoache, 1983), we obtained further evidence of early progress in children's ability to exploit arbitrary cues (i.e., cues that are not intrinsic to the hiding place itself). Two of the conditions in this experiment were direct analogues of the Natural and Landmark conditions of the previous study. In one (Container = Location), four visually distinctive containers (a small box, a tin can, a basket, an overturned flower pot) served as the hiding locations, and the object (a piece of candy) was hidden in one of them on each trial. In another condition (Container = Cue), the same containers were again used, but this time they were simply potential cues to the location of the hidden candy. Each of the containers was attached to the top of one of four identical wooden boxes, and the candy was hidden in one of the boxes. Thus, in the first condition the four containers were themselves the hiding places; in the second condition the same containers were potential cues to indicate which box held the candy. In the third condition, color photographs of the

containers were affixed to the tops of the boxes and served as potential visual cues (Picture = Cue). For half the subjects in each of the three conditions, the relative positions of the containers were switched after the candy had been hidden (Move condition), thus eliminating spatial position as a cue and leaving the visual information as the only reliable cue to the current location of the candy. For the other half of the subjects, the boxes were never moved (Stationary).

The results, which are shown in Figure 2, parallel those from the preceding study. In the condition in which the container was itself the hiding place for the object (Container = Location), both old and young subjects did equally well, regardless of whether or not the boxes were moved. In the second condition (Container = Cue), in which the container was simply a cue designating the correct box, an interesting pattern of results emerged. The older children's performance in this condition was equivalent to their performance in the Container = Location condition; they did very well, and it did not matter whether the boxes were moved or not. Thus, the older subjects used the visual distinctiveness of a container equally well whether the container was the actual location of the object or was merely a cue to the correct location. In contrast, the younger children were not able to perform effectively when the same container was the only cue to the correct box (Container = Cue/Move), although when the container cue was combined with spatial location information (Container = Cue/Stationary), the younger children did as well as in the Container = Location condition. Finally, in the Picture = Cue condition, the results were essentially what one would expect, given the existing literature with delayed response tasks. The pictures, which were probably not highly attractive or familiar to young children, substantially assisted the retrieval efforts of the older subjects when they were combined with stable spatial position (Picture = Cue/Stationary), but they were of limited use to the other three groups.

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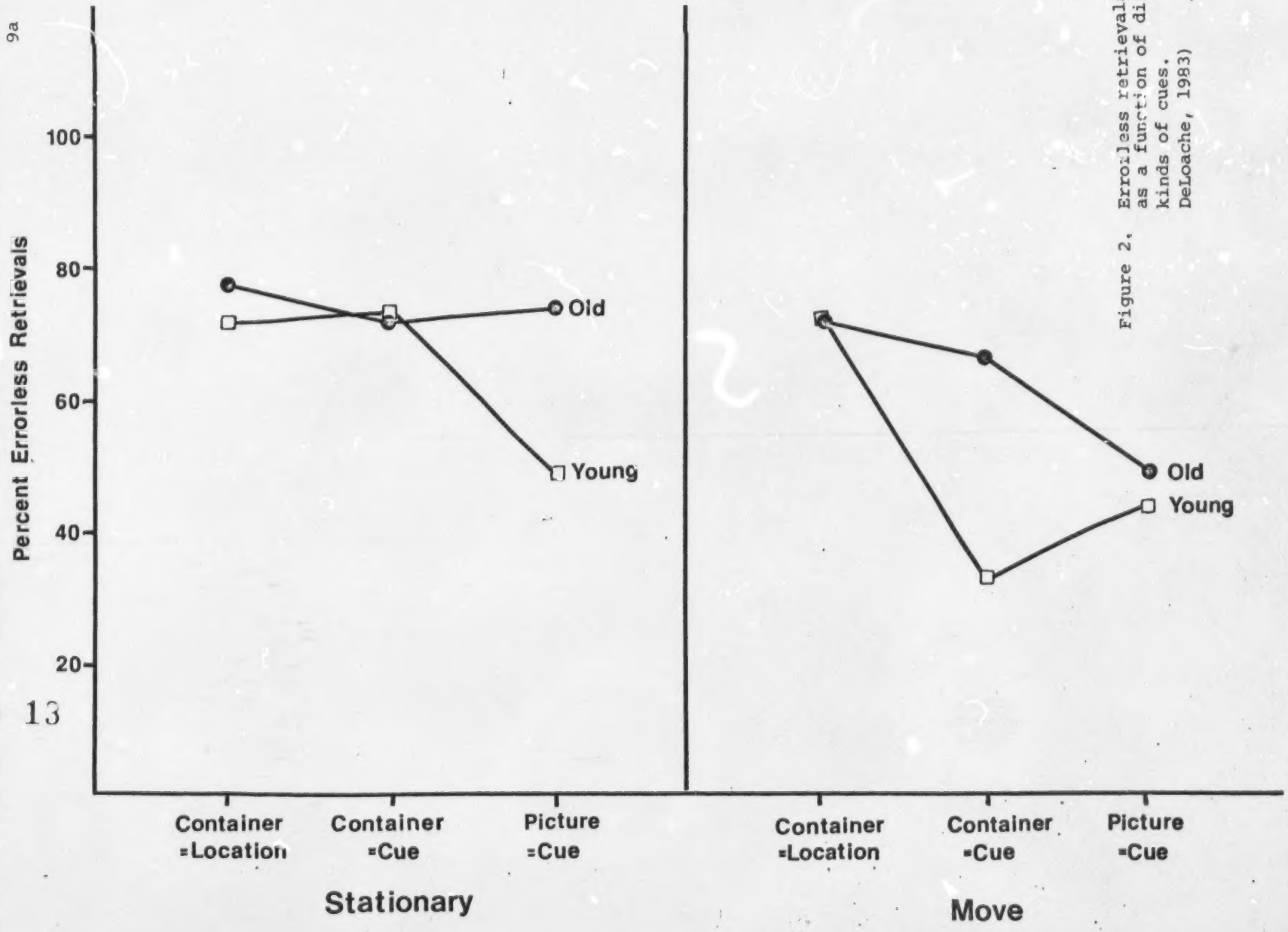

Figure 2. Errorless retrievals as a function of different kinds of cues. DeLoache, 1983)

This experiment thus replicates and extends the finding of the landmark study concerning developmental differences in very young children's use of visual information to guide search. In both studies, both age groups searched quite competently for objects hidden in distinctive locations. To put it another way, there were no age differences when there was a direct relationship between the hidden object and a distinctive hiding place. Age differences did appear when the relation between the object and the information specifying its current location was less direct, so that the child himself had to provide the link between them (as in the Landmark and Container = Cue conditions). The older, but not the younger child, seemed to actively exploit the available cue, transforming it through his own mental activity from a potential to a functional cue.

One particularly interesting and informative aspect of these data concerns the performance of the younger children in the Container = Cue/Stationary condition. Their performance was the same as that of the older children in this condition, and they did much better than the other younger groups in the Picture = Cue conditions. This indicates that the younger children were not oblivious to the container cues--they did perform better when the containers were added to consistent spatial position information than when only the relatively nonsalient picture cues were available. This finding suggests that the age difference found in both studies for the use of arbitrary or indirect cues is probably a retrieval, rather than an encoding, effect. The younger children do notice the arbitrary cues, but they do not actively exploit them to guide search, as the older children do. These data lend further support to our interpretation of the age difference as having to do with the development of early, simple strategies for exploiting information.

When the results of these studies are combined with other research on memory for the location of a hidden object, the following developmental progression

is clear in very young children's use of available cues. By 24 months or even before, children are capable of using perceptual information that is intrinsic to the hiding place itself, such as the distinctive hiding locations used in the hide-and-seek game and the container study or differences in the size of a set of containers (Daehler, Bukatko, Benson, & Myers, 1976). Young subjects can also utilize a matching picture cue, one that bears a pre-existing, non-arbitrary relation to the hidden object (Ratner & Myers, 1980). A highly salient cue that is associated with a reliable spatial cue (as in the Container = Cue condition) may improve their performance but they are unable to use the same cue in isolation. Slightly older children are able to use previously unrelated information; for example, they can exploit a nearby landmark or object as a cue to the relevant location or associate an unrelated picture with the correct box (Blair et al., 1978; Horn & Myers, 1978; Perlmutter, Hazen, Mitchell, Grady, Cavanaugh, & Flook, 1981). Even later, preschool children become capable of planning ahead to make sure a cue will be available in the future (Ryan, Hegion, & Flavell, 1970). Thus, the relevant developmental dimension seems to be the extent to which the young child must actively integrate existing stimulus information or impose his own organization in order to search successfully.

As was discussed earlier, inferences regarding the development of strategic intervention in older children have been based on findings of developmental differences when strategic intervention is possible, and an absence of age differences when it is not. One could argue then that the landmark and container studies reveal an early form of deliberate remembering, but such an interpretation should obviously not be accepted prematurely. Additional evidence is needed, such as direct observation of deliberate actions undertaken in the service of remembering. Convergent evidence of this sort greatly strengthened the claims that young grade school children were capable of strategic action, and such evidence is certainly no less needed to support any claim for strategic behavior by much younger children.

Precursors of Mnemonic Strategies

So far, I have described one aspect of the behavior of two-year-old children in a memory for location task that is reminiscent of the strategic behavior of older subjects. Are there other such parallels between early and later mnemonic functioning? One of the simplest mnemonic strategies is rehearsal. When we have some information that we want to be sure to be able to retrieve at some future time, we repeatedly check to make sure that we do still recall it and repeat it to make its later retrieval more probable. Everyone is overly familiar with the well-worn example of rehearsing telephone numbers, and we all rehearse other information from time to time, including talks about our research.

In a famous experiment, Flavell and his colleagues reported that children as young as five rehearsed words they were supposed to memorize. The children were observed silently mouthing the words to themselves as they waited for a recall test. Istomina (1975) made similar observations of older preschool children spontaneously rehearsing lists of items they were supposed to remember to "purchase" at a pretend store.

Even earlier evidence of simple mnemonic strategies was reported by Wellman, Ritter, and Flavell (1975) in a memory for location task. Three- and four-year-old children watched while an experimenter hid a toy dog in one of three cups. The experimenter then left the room for 40 seconds, instructing the children either to "remember where the dog is," (remember condition) or simply to "wait here with the dog" (wait condition). The children in the remember condition engaged in several simple behaviors that appeared to serve a mnemonic function. They looked at, pointed to, and touched the baited cup more often during the delay period than did the subjects in the wait condition,

Wellman et al. (1975) also reported a few dramatic examples of behaviors whose sole function seemed to be in the service of remembering. One was visual rehearsal, best exemplified by one subject who looked at the baited cup and

nodded her head yes, looked at the unbaited cups and shook her head no, then again looked at the correct cup nodding affirmatively. Another strategy was to make the baited cup distinctive; for example, one boy kept his hand on the relevant cup during the entire delay interval. Wellman et al. have thus shown behavioral analogues in preschool children of the more complex strategies of rehearsal and elaboration present in older subjects. Furthermore, the use of these simple strategies correlated positively with memory performance; children who exhibited the strategic behaviors tended to achieve higher memory scores.

A group of two-year-olds observed by Wellman et al. (1975) in the same task gave no evidence of any of the deliberate behaviors exhibited by the three- and four-year-olds. However, this negative result is inconclusive because, as the authors point out, the task was not really appropriate for two-year-olds. Fully a third of them failed to complete even three trials, often because they were unwilling to remain alone in the testing room. Also, they may not have fully comprehended the verbal instructions. The question remains as to whether children younger than three years of age might be capable of engaging in some kind of mnemonic activity.

Our initial two attempts to find evidence of deliberate mnemonic effort of the sort observed by Wellman et al. were unsuccessful. In one case, we compared the rate of errorless retrievals when children received explicit memory instructions with their performance in what was ostensibly a non-memory condition. The memory condition was the standard hide-and-seek task, in which the child is told at the time of hiding to "try to remember where Big Bird is hiding so you can get him when the bell rings." In the non-memory situation, the child was told, "Big Bird is tired and needs to take a nap." The toy was then concealed in the same manner as in the regular task, but no mention was made that the child would be expected to retrieve the toy. The experimenter merely said that she was "setting the alarm clock so Big Bird will know when

to wake up." Just one nap trial was administered, and it always preceded the regular hide-and-seek trials, since the memory demands actually being placed on the child would immediately become apparent. The results were unambiguous: every one of the 16 two-year-olds (22 to 28 months) retrieved the toy in the nap task. Thus, advance warning that a memory demand will be made is not required for young children to remember the location of a hidden toy. As long as the hiding of the toy is a meaningful activity to them, they generally remember its location with no special effort.

In the second unsuccessful attempt, we compared errorless retrievals as a function of whether the child spent the delay interval in the same room in which the toy was hidden or in a different room. Our reasoning was that if a child did the sort of things that facilitated the performance of the Wellman et al. subjects, he would do better when the hiding place remained in view throughout the interval, i.e., when he was given the opportunity to engage in those behaviors. However, there was no difference in errorless retrievals whether the child waited in the same room as the hiding place, and thus had visual access to it during the delay interval, or in a different room.

In both the above studies, we had looked for an effect on the rate of errorless retrievals, and had found none. This may be in part attributable to ceiling effects in the children's performance: subjects in the hide-and-seek task often achieve perfect or near-perfect scores for errorless retrievals. Our first positive evidence that children younger than two years of age do exhibit some of the behaviors observed in the Wellman et al. (1975) study came from a pilot study that had been designed for another purpose, and from a measure other than errorless retrievals. In that study (Cassidy, 1980), 22-month-old children's performance in the hide-and-seek task was compared for two different settings--their own homes and a laboratory playroom. Our original motivation was to see if the excellent performance we had obtained in previous

work with the hide-and-seek game (DeLoache & Brown, 1979, 1983, in press) might be in part attributable to the fact that the children had always been tested in a very familiar environment. We thought that the young child might have a well-formed schema for his own livingroom that would make it easier to remember where within that environment a toy has been hidden. The laboratory playroom was furnished like a regular livingroom, but was unfamiliar to the children. Cassidy (1980) found that errorless retrievals did not differ as a function of the environment in which the hide-and-seek task was embedded, but she informally (and alertly) observed that the children did engage in several behaviors reminiscent of those reported by Wellman et al. (1975). Furthermore, they seemed to do so more often in the unfamiliar laboratory than in their own homes. We have since conducted two additional experiments investigating this phenomenon.

In those experiments (DeLoache, Cassidy, & Brown, 1983), two observers carefully recorded the behavior of 20-month-old children (18 to 24 months in age) during the interval between when they saw the toy hidden and when they were allowed to search for it. We found that the children often interrupted their play with a set of attractive toys to return their attention to the ongoing memory task, engaging in a variety of target behaviors that indicated they were still preoccupied with the memory task. One such target behavior was relevant vocalization. The children frequently talked about the toy "Big Bird"), the fact that it was hidden ("Big Bird hiding"), where it was hidden ("Big Bird chair"), or about their plan to retrieve it later ("Me find Big Bird"). Other target behaviors included looking or pointing at the hiding place, hovering near it, and peeking at the toy or attempting to retrieve it early. These behaviors resemble the mature mnemonic strategies of rehearsal and monitoring, and they could function to keep alive the information to be remembered, that is, to remind the child of the toy and its location. The data thus suggest that children younger than

two years of age may in some rudimentary way be sensitive to the memory demands of the task.

But do these target behaviors qualify as mnemonic strategies, or even as precursors of strategies? On the one hand, there was no relationship between the occurrence of the target behaviors and memory performance; that is, children who exhibited more of the target behaviors were not necessarily more successful at retrieving their toy. Thus, we did not find the facilitative effect one would normally expect from mnemonic strategies (although the fact that most children's performance was at or near ceiling makes interpretation somewhat problematic). On the other hand, some additional data that we have show that the target behaviors are in many other ways analogous to later, more sophisticated strategies.

For one thing, the children performed the target behaviors differentially as a function of the familiarity of the environment in which the task was embedded, and the familiarity of the task itself. In both studies we compared the behavior of children playing the hide-and-seek game in their own homes versus in a laboratory playroom. One study used a within-subjects design in which each child was observed in both settings, with the order of the settings counterbalanced. As Figure 3 shows, in both experiments, significantly more target behaviors occurred in the laboratory setting than in the home.

Why should very young children be more oriented to a hidden object in an unfamiliar laboratory than in their own homes, especially given that there was no difference in their rate of errorless retrievals in the two settings? One possibility is that when playing the memory game in an unfamiliar setting the children may have less confidence in their ability to remember where the toy is hidden, so they do things to keep alive their memory for its location until they are permitted to retrieve it.

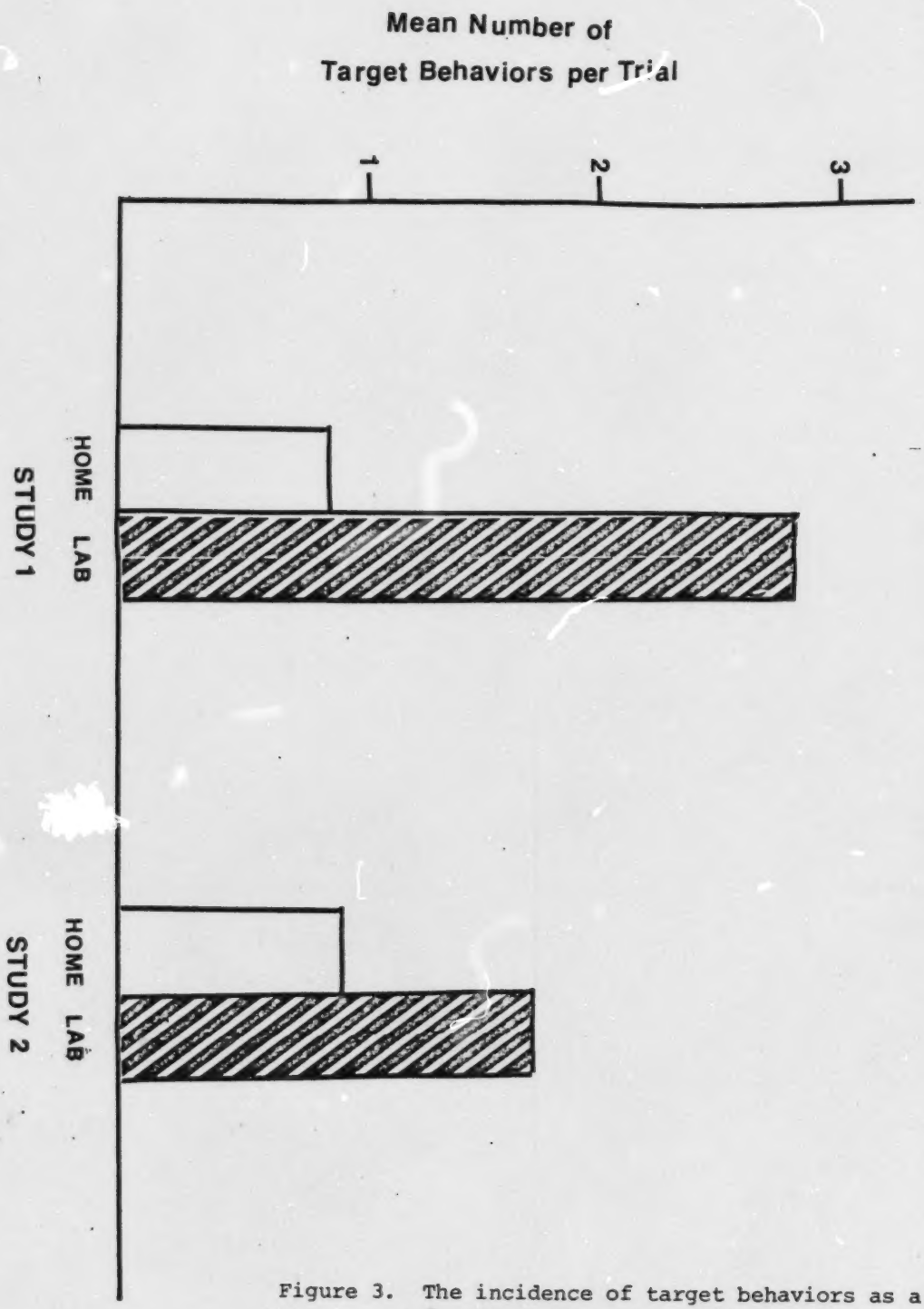

Figure 3. The incidence of target behaviors as a function of setting. Significantly more occurred in the laboratory setting in both studies. (Study 1 used a between-subjects design, and Study 2 was within-subjects.) (DeLoache, Cassidy, & Brown, 1983)

This supposition is strengthened by the fact that in the within-subjects study significantly more target behaviors occurred on the first day of observation, during the children's initial exposure to the memory task, than on the second. The overall mean number of target behaviors for the lab-home and home-lab groups dropped substantially and significantly from Day 1 to Day 2, as shown in Figure 4. The days effect was especially clear in an additional group of subjects who were tested only in the laboratory on two successive days (the lab-lab group). Thus, in two different situations where very young children might be expected to feel less confident--being tested in an unfamiliar setting or participating in an unfamiliar task--they actively monitor the situation and themselves. These two familiarity effects combine so that the condition that produced by far the most target behaviors was when the child's first exposure to the hide-and-seek game was in the laboratory, while the least occurred when the familiar game was played in the child's own home on the second day.

The question remains as to whether these target behaviors are specifically in the service of memory. To address this issue we tested two more groups of 20-month-old children in variations of the hide-and-seek game that removed the memory requirement. We wanted to see if the children would still exhibit the target behaviors even if they were not required to remember the toy's location. For one group the main modification to the task was that the toy remained visible throughout the interval. At the time of hiding, the experimenter said to the child, "Big Bird needs to take a nap now, and when the bell rings, you can go and get him up." The toy was then placed so that it remained visible (e.g., instead of hiding the toy under a cushion, the experimenter placed it on top of the cushion). For the second group, the memory burden was removed from the children in a different way. This time, everything was the same as in the standard hide-and-seek game except that instead of the child retrieving the

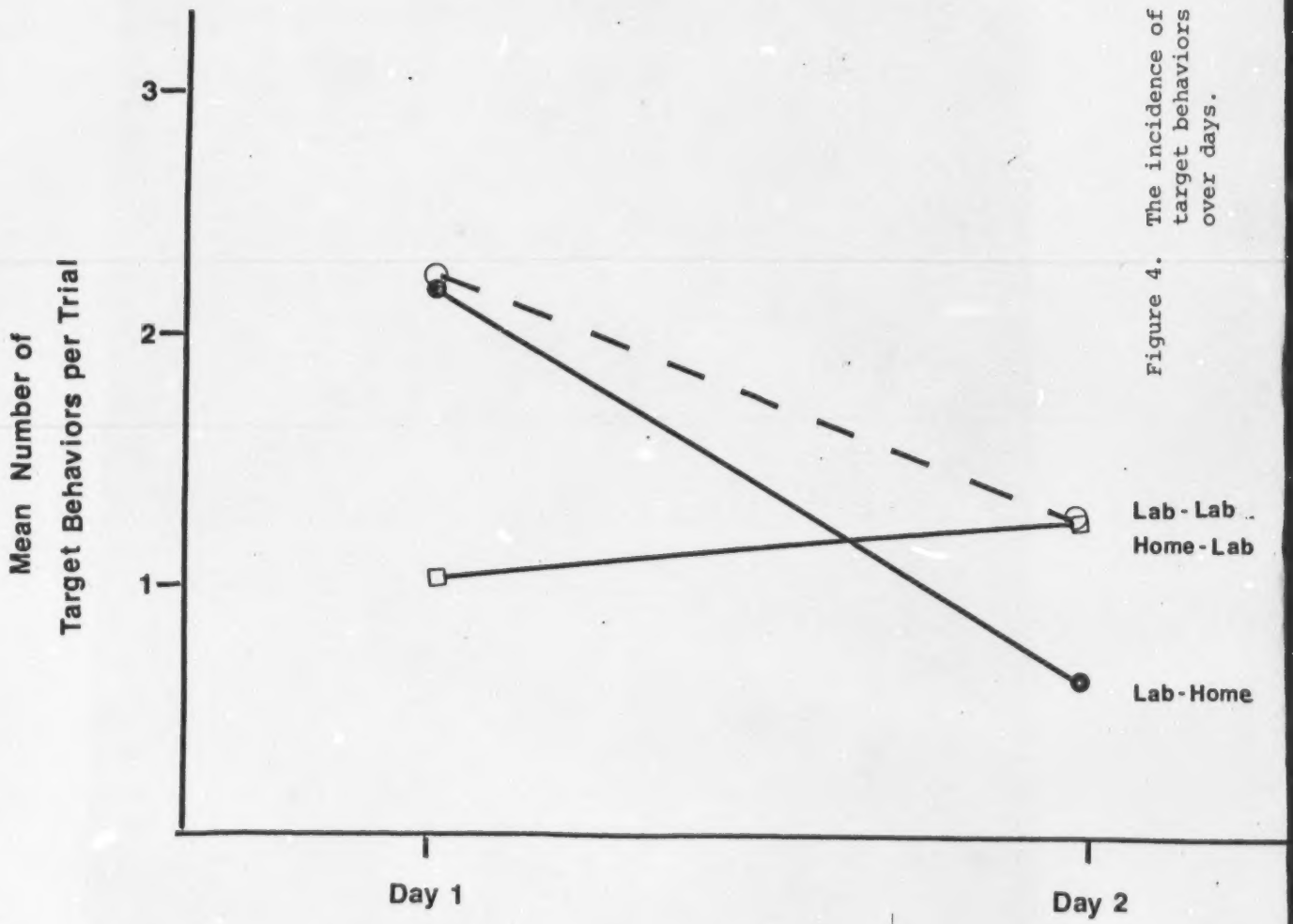

Figure 4. The incidence of target behaviors over days.

toy at the end of the interval, the experimenter retrieved it. In both those situations, in which there was no necessity for the child to remember where the toy was in order to retrieve it later, very few target behaviors appeared, significantly fewer than in the standard memory task (see Figure 5). Thus, when the children did not bear the responsibility for retrieving the toy themselves, they seemed unconcerned with its whereabouts. When the toy was visible during the interval, the children ignored it; when the toy was invisible, so they had to retain its location in memory, they remained preoccupied with it. To rephrase a familiar term used for the pre-object permanence child, we might characterize the behavior of our subjects as, "in sight, out of mind."

It seems reasonable then to interpret the target behaviors as reflecting a very early natural propensity to keep alive what must be remembered. The behaviors we observed arise spontaneously in the course of the memory task as a function of the child's uncertainty about the outcome of the task. Later, more elaborate mnemonic strategies may harness and build upon such simple, spontaneous activities, transforming them into increasingly deliberate and planful actions in the service of memory.

As a footnote to this discussion, I would like to mention one especially interesting behavior that we observed a few times in the regular hide-and-seek task (too seldom to analyze). After watching the experimenter hide the toy, sometimes a child would briefly check a hiding place used on a previous trial (most often the immediately preceding trial). While this behavior was fairly rare (only six or seven subjects ever did it), it is intriguing in light of the fact that the most common error made by young children in memory for location tasks is searching a location that was correct on an earlier trial. It is as though our subjects were reassuring themselves of the irrelevance of the old location, eliminating it as a potential distractor, and it is difficult not to interpret this behavior as reflecting deliberate mnemonic intent.

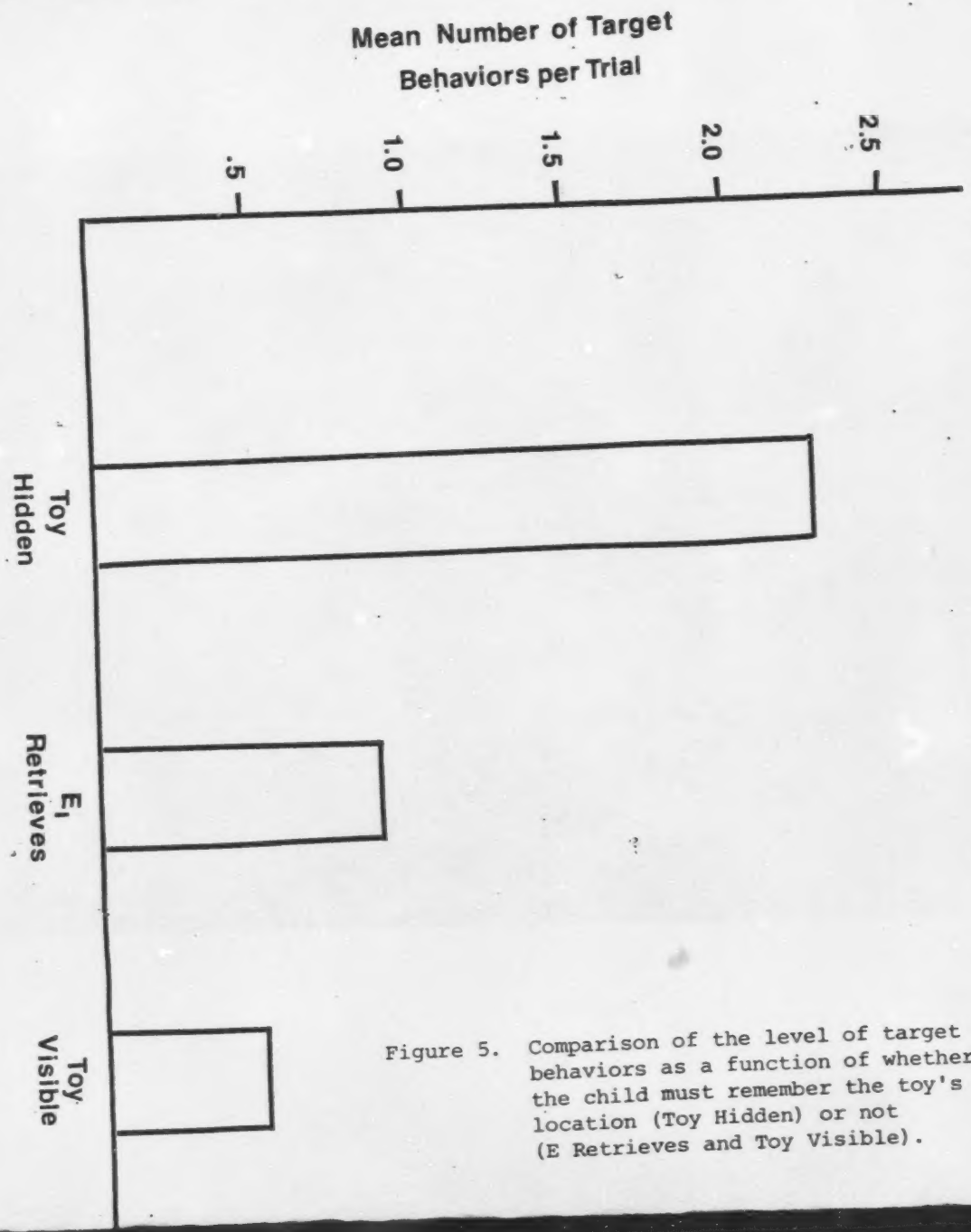

Figure 5. Comparison of the level of target behaviors as a function of whether the child must remember the toy's location (Toy Hidden) or not (E Retrieves and Toy Visible).

Organization of Memory-based Searching

In the last study to be discussed here (DeLoache & Brown, in press), we examined the organization of spatial search. We asked whether very young children are capable of assessing the current state of their own memory and then using that assessment to organize their subsequent behavior. We know that older subjects can. In internal memory tasks, children as young as kindergarten age allocate retrieval effort based on subjective certainty or feeling of knowing judgments: the more certain they are that they know something that they cannot immediately retrieve, the more extensive and persistent are their efforts to retrieve it (Posnansky, 1978; Wellman, 1977).

To see if subjective certainty influences how young children search for an object in the environment, we employed a surprise procedure, a technique frequently used in object permanence research to illuminate the infant's understanding and expectations about objects (e.g., Charlesworth, 1969; Gelman, 1972; LeCompte and Gratch, 1972; Ramsay and Campos, 1978). On two of six hide-and-seek trials, the experimenter hid the toy as usual, but then surreptitiously moved it without the child's knowing it. After the first Surprise trial, the child was always informed that the experimenter had moved the toy and that she had put it in a shopping bag she had brought with her. She explained that, "Big Bird wanted to play a trick on you so I helped him hide in my bag."

We expected that the length or persistence of the child's search of the correct location would reflect his level of certainty: the more certain the child is that he knows the correct location, the longer he should continue searching there after he fails to find the toy right away. We compared the length of the children's first search on Surprise trials with all Error trials that occurred, that is, all the times they mistakenly went to the wrong place first. Note that in both cases, the child's initial search has failed to

retrieve the toy. On Surprise trials he is in fact at the correct location so he should be confident of his choice. On Error trials the child is wrong--he may have forgotten the correct location or become confused--so he should be considerably less certain.

Two age groups of children participated in this study, an older group whose mean age was 27 months (25 to 30 months) and a younger group with mean age of 21 months (18 to 24 months). For both age groups, the first search was significantly longer on Surprise trials, when they were in fact correct, than on Error trials, when they were mistaken. There was also a tendency to re-search the correct location on Surprise trials. A good example of a persistent search is the Surprise trial behavior of a 23-month-old boy: he looked under the couch cushion where his toy had been hidden, then pulled the cushion completely off the couch and examined the area, turned around to say "No!" to his mother, and then turned back and briefly checked the correct hiding place one more time. Thus, for both the younger and older children, their subjective certainty determined how persistently they searched.

These results, which concern the retrieval of an object from the external environment, are analogous to those obtained with adults and older children (Posnansky, 1978; Wellman, 1977) for the retrieval of internally stored information. In both cases, children's retrieval effort is based on their assessment of their own memory state--how much they think they know or how well they think they know it. That children are capable of this form of metamemory earlier in an external memory task such as the hide-and-seek game is consistent with other research showing that metamemory skills are generally exercised earlier with respect to external variables (Gordon and Flavell, 1977; Yussen and Levy, 1977).

We also examined the subsequent searching that the children did on Surprise and Error trials. An intelligent response to the surprising absence of an

object at its remembered location is to search plausible alternative locations. Imagine an adult who fails to find his car keys on the coffee table where he remembers leaving them. He would probably search all around the table surface in case he had misremembered the precise spot, and he might check to see if the keys had been brushed off the table onto the floor. Or he might find out if someone else moved the keys. Thus, this hypothetical adult selects from all the potential locations in the room those places that are near or in some way related to where he remembers the keys should be. In other words, he confines his searching to places that would be plausible locations of the keys if his memory for where he left them is essentially correct.

After their initial unsuccessful search on Surprise and Error trials, the children usually (71% of the trials) went on to search one or more additional locations. We examined all additional searches on Surprise and Error trials to see if the children's behavior was like that of the intelligent adult. A search was scored as intelligent, or "related," if it fell into one or more of the following three categories: (1) the child searched a place that was near to the correct location (for example, if the toy had been hidden under one couch cushion, the child went on to look under the next cushion or behind the couch); (2) the child searched an analogous location (if the toy had been hidden under a pillow at one end of the couch, the subject looked under a different pillow at the other end of the couch or on a chair); (3) the subject sometimes looked in the bag to which the experimenter had moved the toy on the first Surprise trial.

We had expected differential searching on Surprise and Error trials, and in particular, more related searching on Surprise trials. If you are sure that an object was hidden in a given place, and it is not there, then it makes sense to search other places related to it. If you are not really certain of the original location of the object, then it is not so clear where to search next

(unless you happen to suddenly remember the correct location). As shown in Figure 6, this pattern was observed for the older subjects, but not for the younger ones. When the younger children failed to find their toy, regardless of whether it was a Surprise or an Error trial, they tended to search in places where it had been hidden before, reminiscent of the typical error in delayed response tasks of searching for an object where one has previously found it (Daehler et al., 1976; Loughlin & Daehler, 1973; Horn & Myers, 1978; Perlmutter et al., 1981; Webb, Massar, & Nadolny, 1972), as well as the Stage IV error in object permanence research (Harris, 1975).

The older children displayed qualitatively different searching on Surprise and Error trials. On Surprise trials the old subjects almost always (95%) began their additional searching at locations that were in some way related either to the correct location or to their previous Surprise trial experience, and three-fourths of their total Surprise trial searches were so related. In contrast, less than one-fourth of their Error trial searches were related. Thus, the older, but not the younger, children used their own sense of certainty to organize how they searched for a missing object.

The related Surprise trial searching of the older children suggests that they (like the hypothetical adult with the lost car keys) may have generated plausible hypotheses to explain the toy's absence which then guided their subsequent search efforts. For example, their frequent searches of locations that were analogous to the correct location suggests that they sometimes assumed they must have misremembered a detail about the toy's location, such as which specific one of a category of spatial locations it was. Supporting examples include a child's going from the couch pillow under which the toy was hidden to a different pillow at the other end of the couch or to a pillow on a chair.

The older subjects occasionally seemed to consider the possibility that some intervening event had spatially displaced the toy. A 30-month-old

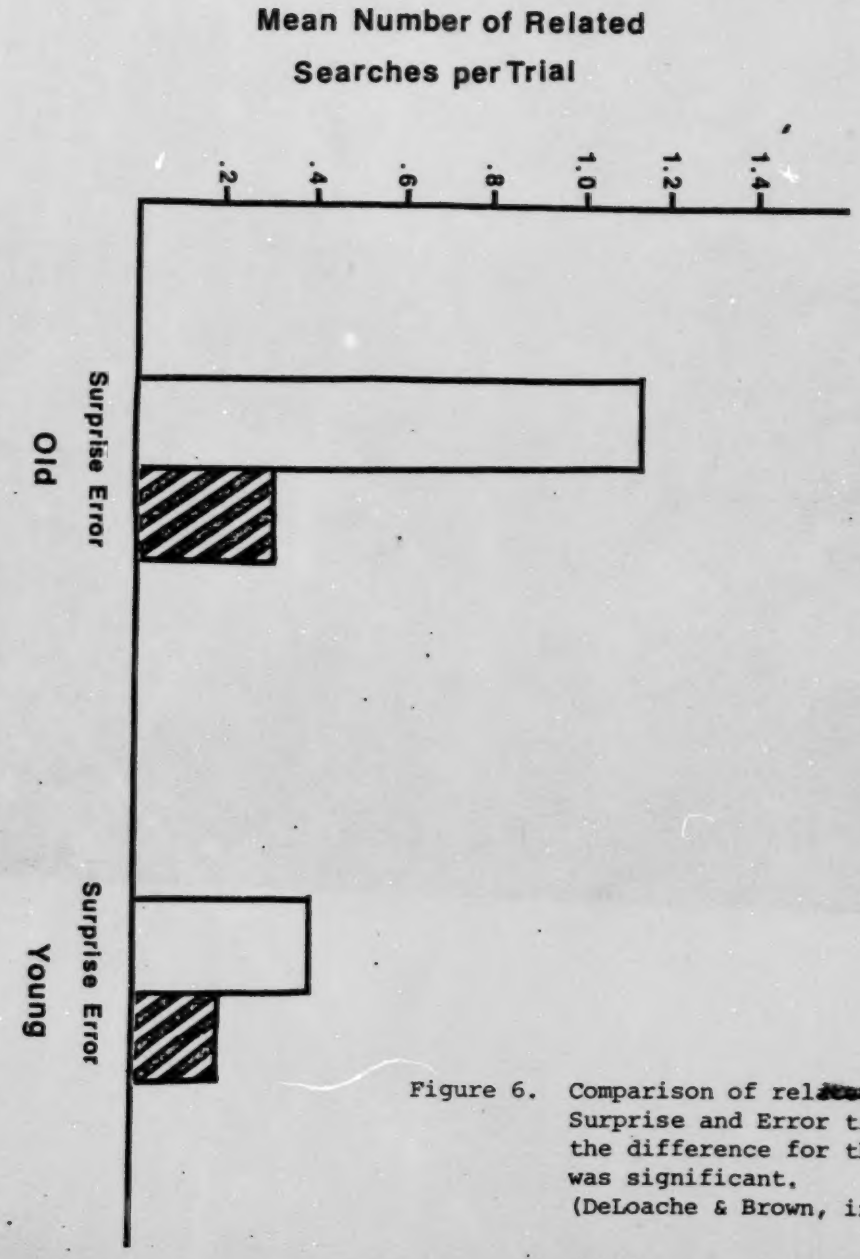

Figure 6. Comparison of related searching on Surprise and Error trials. Only the difference for the older subjects was significant. (DeLoache & Brown, in press)

searched both under and beside the couch in which his toy had been hidden. Another subject explicitly verbalized this hypothesis: he looked in the desk drawer in which his toy had been hidden, said "Did Mickey Mouse fall out?", and then proceeded to search behind the desk.

Some children also realized that a social agent might be responsible for the toy's absence. On the second Surprise trial, several subjects inferred (correctly) that the experimenter had again moved their toy; they went directly from their initial search to the experimenter's bag, the place to which the toy had been moved on the first Surprise trial. A 29-month-old girl whirled around from her initial search of the correct location, yelling to the experimenter, "In your bag!". She then ran immediately to look in the bag, saying, "Jackie, you took him."

Additional evidence for the assertion that the older children were trying to figure out where their toy was likely to be is the fact that many of their Surprise trial searches were of completely new locations (i.e., ones that had never been used as hiding places), and most of these new locations were related to the correct one. This tendency to search new related locations on Surprise trials indicates that the older children are able to conceive of several possible locations, and they select potential locations to search on the basis of their relation to the original hiding place. While the younger subjects tended to search locations that had been previously associated with the object, the older children did something much more active than simply searching at the location with the strongest memory trace. They ignored past associations and selected places to search because they were plausible alternative locations for the toy. This age difference in related searching signals an increase in the flexibility with which the child reorganizes his search behavior. When confronted with failure, the younger subject simply reiterates a previously successful response, but the older child tries a new solution, based on his construal of the present situation.

Primitive Self-Regulatory Skills

Let me summarize and integrate the research I have described. Our investigation of very young children's memory performance has revealed surprising competence, both in terms of the level of performance and the processes underlying it. Two-year-old and even younger children are very good at remembering spatial locations; in fact, their performance is often virtually perfect. They are sensitive to memory demands placed on them in some circumstances, and they exhibit a propensity to keep alive information to be remembered, even though such behaviors do not seem functional in the particular context in which we observed th

When mediated memory is essential for good performance, developmental differences appear in the period between 1½ and 2½ years of age, suggesting the emergence of simple forms of self-regulation. For one thing, the scope of information that can be exploited expands as the child becomes capable of integrating arbitrarily-related information, exerting cogntive effort to transform potential cues into functional ones. The flexibility of young children's problem-solving efforts also increases. If their initial effort fails, two-year-olds are able to initiate a creative solution (e.g., search a new but related location), while younger subjects fall back on responses that were successful at a previous time.

The mnemonic achievements I have described for very young children are fairly impressive, but not awesome. The two-year-old child may be more of a mnemonist than we had suspected or given him credit for, but he is still a novice. Thus, we have a sort of "doughnut hole" phenomenon: you can either be impressed by the unsuspected sophistication that young children are capable of displaying in some situations, or you can emphasize the limited domain of these primitive skills. I should like to avoid either of these extremes; I want to have my doughnut and eat it too. It is important that those of us who

tend to be impressed by what we are discovering about young children's capacities are not blind to the holes in their competence. And it is equally important that those who tend to see the toddler as so much unrisen dough also recognize the extensive array of ingredients already present. We will make progress only if we neither exaggerate nor belittle the cognitive achievements of very young children.

What then are the limitations on the simple forms of early self-regulation that we have observed, and how do young children overcome them? In terms of limits, the abilities I have described are almost certainly restricted to external memory tasks in which the environment assists the novice mnemonist. However the young child represents a hidden object and its spatial location (which is an interesting question itself), there are abundant cues present to help him retrieve both his representation and the actual object. The child has to recall the existence of the hidden object, but he only has to recognize its location. Scanning around the room is a simple and effective way of reminding himself of the toy's location, and young children often do this. What I am suggesting then is that the young child's fledgling regulatory efforts occur when the organization present in the external environment minimizes the amount of internal organization that the child himself must produce.

Another limitation on the young child's mnemonic activities is the extent to which he has conscious control over them. I seriously doubt that the average two-year-old queries himself, "What can I do to help me remember?" Rather, early regulation emerges in the context of ongoing activity in which the child has adopted the goal of retrieving an object at a slightly later time. The fact that the target behaviors occur almost exclusively when there are memory demands placed on the child indicates some sensitivity to the need for future retrieval.

The young child does seem to assess his own momentary sense of confidence or certainty, and that self-assessment influences his immediate behavior. When

he is uncertain or insecure, he repeatedly returns his attention to the task demands. When he is very confident of his judgment, he is highly persistent in the face of failure. However, only the older children we observed (i.e., those over two) were able to use their own feeling of knowing as a basis for organizing their subsequent behavior.

The young child also seems to make some assessment of the difficulty of the task he faces; our subjects engaged in the strategy-like target behaviors more often in one setting (the laboratory) than in the other (the home). However, the data also reveal that their task analysis is imperfect. There is no evidence that the hide-and-seek game is actually any more or less difficult in one setting or the other. It may be that the children mistakenly use a general sense of insecurity aroused by being in an unfamiliar setting as information relevant to the task. The child has to learn to judge when such behaviors are actually necessary to improve performance and when they are irrelevant.

This brings us to a final way in which the target behaviors we observed in our two-year-old subjects differ from mature strategies. While these target behaviors were similar in form to the deliberate mnemonic behaviors reported by Wellman et al. (1975) for older children, there was no evidence that they served the same function of improving memory performance.

There are various explanations for why the strategy-like target behaviors did not relate to memory performance. One is purely artifactual--the ceiling effect present for the memory performance measure may have obscured a true relationship. If this is so, then a more difficult version of the hide-and-seek task, in which ceiling performance is not so common, might yield a correlation between target behaviors and memory performance. In Siegler's (this volume) work on addition, strategy use was correlated with performance only for more difficult problems. Additional research is needed to resolve this matter. We are planning to use a multiple-object hide-and-seek task,

in which three toys are hidden per trial and in which the overall performance will be poorer (DeLoache & Brown, 1979), to see if engaging in the target behaviors might facilitate retrieving the objects.

We would not be surprised to obtain such a result. However, we would also not be surprised if we again found no correlation between the occurrence of the target behaviors and young children's memory performance. It seems to us perfectly reasonable that there may in fact not be a very direct relation between incipient strategies and performance. These behaviors may arise spontaneously in the midst of goal-directed activity, but only gradually become harnessed in the service of the goal. Thus, even though the target behaviors that our very young subjects spontaneously exhibited were not adaptive for the task in which the children were involved at the time, they may be adaptive in the long run. That is, they may provide a basis for the evolution of later more deliberate, finely-tuned, and instrumental mnemonic strategies.

From what has been presented here, we can summarize what we might generally expect precursors or immature forms of self-regulatory skills to look like. First, they will almost certainly not be perfect versions of the mature strategies; they will resemble them in some ways, but not in others. Nascent skills are probably exercised in limited domains, appearing only when there is a near ideal match between the child's current skills and the amount of organization demanded by the task at hand. The fragile skills probably first appear within the context of immediate, ongoing activity, rather than in a planful or self-conscious way. The means/end distinction may at the outset be fairly fuzzy, with the strategy only gradually coming to serve as an explicit means subordinated to the achievement of a given goal.

In conclusion, I have argued that we have evidence for the existence in very young children of rudimentary forms of self-regulation. We have learned something about what very early manifestations or precursors of later skills

are like. We know what the mature forms are like: the vast literature on mnemonic strategies leaves us quite well informed in that regard. What we need now is a better understanding of the refinement of these primitive, limited mechanisms into the complex, adaptive skills that older people possess. How does a young child who repeatedly looks at the place her toy is hidden turn into an adult who nervously rehearses for her research presentation to a group of distinguished colleagues?

Footnote

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